



THE LIFETIME SURVEILLANCE OF ASTRONAUT HEALTH

Newsletter

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Editor's Note: The first two articles in this edition provide summaries of peer-reviewed journal articles that might be of interest to both short- and long-duration crewmembers. As with any summary, the authors' reviews may not be fully complete. We encourage the reader to refer to the original article if there are concerns or additional information is desired.

Protecting Bone Mass During Space Flight

By: Jacqueline Charvat, PhD & Claudia Méndez, MPH

There are 206 bones in the human body that offer support, protection, and allow us to move freely on Earth and in space, however, bone density loss during long-duration space flight is a known risk of major concern. A team of researchers led by Dr. Scott M. Smith of NASA/Johnson Space Center's Biomedical Research and Environmental Sciences Division recently published a study showing that a combination of appropriate nutrition and resistance exercise can mitigate bone loss and reduce the risk of space flight induced osteoporosis.

For astronauts on the Mir space station, the only forms of exercise available during long-duration space flight were aerobic (treadmill and cycle) and muscular endurance exercises (such as elastic expanders). Aerobic exercise, however, is not meaningfully effective in reducing bone loss. As on Earth, weight bearing movement and exercise is required to maintain bone mineral density. Ground research had shown that resistance exercise has a stimulatory effect on bone remodeling in spaceflight analogs (e.g., bed rest). For astronauts on the International Space Station (ISS) a

greater array of exercise modalities is available. In 2000, an interim resistive exercise device (iRED) was launched to ISS with the ability to perform eight different exercise protocols. Studies comparing the iRED to the aerobic and muscular endurance exercises available on Mir determined there was no improvement in bone protection. In 2008, the Advanced Resistive Exercise Device (ARED) was launched. This device has much greater resistance capability and a larger variety of exercises than the iRED. Along with exercise, nutrition plays a major role in overall health. During long duration space flight, nutrition is often compromised as many astronauts do not meet their required energy intake. It has been estimated that some astronauts consume only 70-80% of their required energy needs, which leads to a 5-10% loss of preflight body mass. Not only are some astronauts not meeting their total energy needs, they are also not meeting their daily vitamin D intake requirements. In 2006, the amount of vitamin D supplements provided on ISS was doubled, to 800 IU vitamin D/day.

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This study compared the differences in bone mineral density, bone mineral content, bone formation and breakdown (resorption) markers, and nutritional factors in eight astronauts who used the iRED and five astronauts who used the ARED. All crew members had access to the treadmill. Blood and urine samples were collected preflight, in-flight, and postflight. Dual-energy X-ray absorptiometry (DXA) scans were done before and after flight to determine changes in bone mineral density and bone mineral content. Dietary intake was assessed through the use of food frequency questionnaires in which crewmembers recorded their intake once per week.

The study found that there was no change in the total body mass pre- to postflight for either the iRED group or the ARED group. There was also no difference in the level of exercise adherence for either group, with both achieving about 75% of scheduled exercise sessions. However after space flight, the ARED group had more lean tissue mass (i.e. muscle) and less fat mass than those in the iRED group. The study found that ARED crewmembers had higher energy intakes (>90% of requirements) than the iRED crew members, and that both groups had good vitamin D status.

The ARED exercisers, with higher energy intake and good vitamin D status did not lose any bone mineral density after flight compared to preflight. The blood and urine biochemistry documented that while bone breakdown was increased in flight, there was a trend for increased bone formation, which allowed for the maintenance of bone mineral density.

This is the first study to document preservation of bone mass during flight as measured in the whole body and in specific regions. While bone mass is protected, the bone itself is being remodeled through continuous formation and resorption, and

questions remain about whether this affects bone strength and fracture risk. Studies are underway to answer these questions. Optimization of exercise protocols and dietary factors may further help to mitigate bone loss during space flight.

This study documented that loss of bone density can be prevented through good nutrition and heavy resistance exercise. Results also showed that vitamin D status can be maintained at optimal levels with about 800 IU/day. Because bone loss is such a critical concern during space flight, it is important to investigate countermeasures that can prevent or reduce the risk of bone loss. Resistance exercise and nutrition are vital for bone health here on Earth and may be especially beneficial while in space.

Full citation: Smith SM, Heer MA, Shackelford LC, Sibonga JD, Ploutz-Snyder L, Zwart SR. Benefits for Bone From Resistance Exercise and Nutrition in Long-Duration Spaceflight: Evidence From Biochemistry and Densitometry. J. Bone Miner Res. 2012 Sep;27(9): 1896-1906.

Link: <http://onlinelibrary.wiley.com/doi/10.1002/jbmr.1647/full>

Do you have a suggestion for a newsletter article?

We'd love to hear about it!

Send suggestions, comments, or questions to:

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Publication Review: Galactic Cosmic Radiation Linked to Alzheimer Disease Pathology in Mice

By: Ambericent Cornett, MS, MPH

Concerns have been raised about the potential for space radiation to cause late degenerative changes to the brain, especially with NASA's current aim of extended duration and deep space missions. The space radiation environment is composed of high levels of protons present during solar flares and a low but constant level of high-energy charged particles (HZE) that include ^{56}Fe . A portion of NASA's research focus has been to understand the possible effects of space radiation on the central nervous system. Previous studies have documented that ^{56}Fe irradiation can cause neuroinflammation, neurogenesis effects, and cognitive impairment in animal models. It is important to recognize that these models, and the model in this article, may not reflect what radiation would be encountered on a deep space mission nor what the outcome would be in a human.

In December 2012, a team of researchers at the University of Rochester published a study on the potential risk of space radiation and the development of pathological changes that are the hallmarks of Alzheimer's disease (AD). In particular the research team investigated the declines in memory and cognition and the development of plaques or abnormal clusters of protein fragments that build up between nerve cells in the brain.

For the study, mice were exposed to ^{56}Fe particles at NASA's Space Radiation Laboratory at Brookhaven National Laboratory and then measured for cognitive abilities and plaque pathology development. Female mice were irradiated at 100 cGy and euthanized at seven months, while males

were irradiated at 10 cGy and 100 cGy and euthanized at 9.5 months. Including controls, 59 mice were used in the study. Females were euthanized early due to experimental concerns, therefore the results in each gender were not comparable.

To assess cognitive and memory impairment, contextual fear conditioning and Novel Object Recognition (NOR) tests of the animals were employed. Contextual fear conditioning assessed hippocampal-dependent memory through recognition of an environment associated with fear of foot shock, which was assessed as percent of time in freezing behavior. There was no significant effect involving radiation in the female mice, but a significant decrease in freezing occurred between the control and irradiated groups. The Novel Object Recognition (NOR) Test allows the mouse to familiarize itself with two objects, and then assesses the time the mouse spends evaluating the objects when one is replaced with a novel object. The NOR paradigm is accepted testing among animal and human subjects, evaluating recognition memory from the neural basis. Short-term, intermediate, and long-term memory can all be assessed. The NOR paradigm operates as a manipulation of retention intervals in an environment without positive or negative reinforcing to measure the subject's habituation and familiarization before the actual testing is conducted. The Recognition Index (RI) is calculated based on the proportion of the total time spent with the object. Significantly different RI scores were found be-

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tween irradiated and control mice in both sexes and at both radiation levels in males.

The radiation-induced defects in learning and memory led to examination of the alterations of Amyloid- β (A β) pathology in the mice brains. A β is one of the most prominent hallmarks of Alzheimer's disease resulting in dense fibril plaques in the brain, indicating the severity and stage of the disease, which has also been studied during the first human trial of a novel amyloid-imaging positron emission tomography (PET) tracer (Klunk, 2004). Male mice showed enhanced A β plaque accumulation with two markers, while females showed no significant change. This increased plaque accumulation could be due to multiple mechanisms, including DNA damage contributing to overall cell dysfunction, glial activation, inflammatory cytokine production, and vascular defects leading to improper clearance of A β .

This mouse model suggests that whole body exposure to ^{56}Fe particle HZE radiation may lead to enhanced mechanisms for pathological progressions that are linked with Alzheimer's disease development. The researchers note that this study does not fully reflect the human condition, and suggest more research should be done with other HZE species at different doses and exposure lengths, reflecting the complex exposure environment of space.

Full Citation: Cherry JD, Liu B, Frost JL, Lemere CA, Williams JP, Olschowka JA, O'Banion MK. Galactic cosmic radiation leads to cognitive impairment and increased a β plaque accumulation in a mouse model of Alzheimer's disease. PloS One. 2012 Jan; 7(12).

This article is available free online at: <http://www.ncbi.nlm.nih.gov/pmc/articles/>

Occupational Surveillance – What is it, and What is LSAH Doing with My Data?

By: Lesley Lee, MS

One of the major efforts underway within LSAH is ramping up our Astronaut Occupational Health Surveillance Program (AOHSP). LSAH conducts occupational surveillance of astronauts by analyzing medical, physiological, hazard exposure, and environmental data to identify health trends and/or adverse health outcomes related to space flight or space flight training. These analyses of the data then help guide astronaut healthcare practices and research at JSC and inform planning, implementation and evaluation of programs to prevent and control spaceflight injuries, disease, or hazard exposures.

Many AOHSP projects, such as some of our current efforts described below, involve teams of interdisciplinary subject matter experts:

Musculoskeletal (MSK): Initiated in 2010 to analyze shoulder and elbow injuries in the astronaut corps, this project has expanded into a comprehensive research effort currently focused on EVA-associated shoulder injury. Analyses include assessing injuries in pivoted versus planar HUTs, whether training density might be related to injuries, and comparing our population to both enrollees in a managed

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care plan at a local orthopedic practice and members of the Armed Forces. As part of this project, our epidemiologists have assembled EVA training data from multiple sources into a single database containing 15,000+ individual training runs and compiled over 20 different datasets for analysis by the MSK team.

Carbon Dioxide (CO₂): Initiated in July 2010 to support the Reliability and Maintainability Assessment Tool (RMAT) evaluation of the relationship between headaches and CO₂ levels. This was initiated in association with a recently implemented flight rule lowering the acceptable CO₂ level on the International Space Station. Inflight reports of headaches, visual changes, other CO₂-related symptoms and CO₂ levels throughout the ISS program were compiled from various sources for this project. Average and peak CO₂ levels were calculated during two periods, 24 hours and 7 days prior to a private medical conference, for the duration of the ISS program. Currently LSAH is working with the JSC Toxicology Lab to refine the CO₂ data and fill in gaps caused by downtime of monitoring equipment.

Visual Impairment/Intracranial Pressure (VIIP): LSAH contributions to a larger VIIP effort have been detailed in previous newsletters. Currently, LSAH is working to incorporate new vision imaging data (both inflight and ground-based) into JSC medical data, and working with JSC physicians to update Clinical Practice Guidelines that will guide treatment of affected astronauts.

Microbiology: LSAH is teaming with the JSC Microbiology Laboratory to determine if certain opportunistic microorganisms (bacterial, fun-

gal, or viral) found on ISS are associated with adverse health outcomes, for example infections, rashes, or gastrointestinal problems. The dataset is currently being compiled for all ISS missions, and it will help inform efforts to improve monitoring (e.g., sampling locations, crew time, hardware) and exposure prevention.

Hearing Conservation: LSAH epidemiologists are working with Dr. Richard Danielson, Manager for Audiology and Hearing Conservation at JSC, to provide each astronaut with an individualized, longitudinal report of their hearing status following each annual exam. These reports help show losses over time as well as compare the individual against the astronaut corps and the general U.S. population.

Cancer Mortality: LSAH epidemiologists are evaluating the data to assess if morbidity and mortality due to cancer are different among the astronaut corps compared to the US population. Medical records will be reviewed to identify cancer events in order to create an Astronaut Cancer Registry maintained and secured by LSAH.

For more information on
occupational surveillance, visit
<http://www.cdc.gov/niosh/topics/surveillance/>

Recent Reimbursement Updates

We've recently received some reimbursement questions regarding annual physical exam travel to Houston and we would like to share this information with you.

- Airline or credit card points used to purchase airfare to Houston cannot be reimbursed. A receipt showing actual cash-value purchase of airfare is required for reimbursement.
- First or Business class airfares or upgrades cannot be fully reimbursed. We can only reimburse for the equivalent cost of economy, coach or special discounted fares.
- "Intermediate" to lower class or the equivalent are the only class of rental vehicle that can be reimbursed.

Wyle is required to adhere to the US Federal Government rules and regulations on travel expenses and per diems. These policies can be found at:

<http://www.gsa.gov/portal/ext/public/site/FTR/file/Chapter301p010.html/category/21868/#wp1201972>

A complete list of updated travel tips can be found in the annual exam invitation packet you will receive during your birth month. If you are unsure about reimbursement, contact Denise Patterson (281-244-5195) in advance of your trip purchase. She can do a cost comparison to tell you what portions of your expenses can be reimbursed.

For Your Information

If you want a copy of your exam results, please complete and sign a release form while you are visiting the Clinic for your examination. The form is called *Authorization for Disclosure of Protected Health Information for Continuity of Care*.

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